INT MISC

PROBLEM SELECTION STATEMENT
FOR
LINE PROJECT FS-INT-1605
WATER YIELD IMPROVEMENT

This project, "Water Yield Improvement in the Intermountain Region," is headquartered at the Forestry Sciences Laboratory in Logan, Utah. Its objectives are: (1) To identify and quantify the morphological characteristics and physiological processes of vegetation which influence quantity, quality, and timing of water yields from watersheds within the range of climatic and edaphic conditions represented in the Intermountain Region; and (2) to evaluate the effectiveness of plant cover alterations, small engineering structures or soil treatments, and evapotranspiration suppressants on the improvement of quantity, quality, and timing of water yields from Intermountain watersheds.

The assigned mission includes these specific segments: determine the physiological characteristics of major vegetation species in relation to transpirational requirements and how nutrition affects water consumption and the persistence and reproduction of selected species; investigate the effects of soil and chemical treatments on evapotranspiration; develop and test vegetation conversion techniques; develop, apply, and evaluate water yield improvement practices on plots and watersheds; and recommend water yield improvement practices based upon economic feasibility. The mission does not presently include weather modification, mechanical drifting of snow, or suppressing evaporation from lakes or reservoirs.

Problem Situation

The Great Basin physiographic province, a major component of the Intermountain Region, yields less water per unit area than any other zone in the United States except the southern desert region. Although local shortages periodically occur, at present the Great Basin has an adequate water supply. However, by the year 2000, the ratio of supply to demand is expected to have fallen to 0.7, indicating that 30 percent more water will be needed to satisfy the projected demands of the Basin's growing industry and human population. A portion of the Region east of the Great Basin drains into the Colorado River system; a system in which the demand for water is already critical, and will become worse as downstream development continues. A large segment of the northern part of the Region drains into the Columbia River system, especially via the Snake River. As a whole, this system is blessed with a plentiful supply of water. Nevertheless, shortages of irrigation water sometimes occur east of the Cascades.

Most of the people in the Intermountain Region reside in the Great Basin, within the states of Utah and Nevada. There are more than a million residents in Utah. Within the next 15 years, this population is expected to increase by about 60 percent; a rate nearly twice that projected for the conterminous United States. Then, 80 percent of Utah's population will live in counties comprising only 4 percent of its land area in a megalopolis immediately west of the Wasatch Mountains. Nevada's population is concentrated in limited areas in a manner similar to that of Utah. Half of its people are in the Las Vegas Valley, where they draw heavily on ground water and water from Lake Mead. An additional 35 percent of the population lives in the valleys of the Truckee, Carson, and Walker Rivers, with Reno as the commercial center. About 8 percent of the population lives in the Humboldt River Basin, and the remaining 7 percent of its people lives in the other four-fifths of the State. The population in the Las Vegas and Reno areas is growing at a phenomenal rate--even faster than Utah's.

Utah has 13 inches and Nevada has 9 inches of average annual precipitation. Large variations in precipitation occur, due mainly to differences in elevation and exposure to moisture-bearing winds. In Nevada, it ranges from less than 4 inches in valleys near Las Vegas, to about 8 inches at Reno, to more than 20 inches at elevations above 7,500 feet. Utah's precipitation varies from less than 5 inches annually on the Great Salt Lake Desert, to more than 50 inches in the high elevation watersheds. Annual runoff in Utah produces 8.5 million acre feet of water, with most of this supply coming from elevations above 7,000 feet. In both States, the monthly streamflow is highest during the snowmelt period of May and June; water yields during these two months are about 60 percent of the yearly total.

Throughout the Region, the high mountainous areas yield water of excellent quality, containing less than 100 parts per million of dissolved solids. However, the converse is true in the lower reaches of some streams, where the dissolved-solid content exceeds 3,000 parts per million. Sediment also lowers the quality of water; and the yields of sediment in portions of the Upper Colorado River Basin in Utah are as great as 2,600 tons per square mile per year.

In the Intermountain Region, more than 20 million acres are covered by vegetation which transpires large amounts of water. Some of these vegetation types are of low economic value and occupy watershed lands which are potentially capable of yielding more water, if practical water-saving treatments can be devised. For example, in Utah alone, approximately 5½ million acres of the pinyon-juniper, mountain brush, aspen, and coniferous forest types occur in precipitation zones of 20 inches or more annually; zones from which water yields are significant. This is only 10 percent of Utah's acreage. A real potential for increasing water yields exists on this small area of what is otherwise a semiarid State.

The quantity of water yielded from the higher elevation watersheds may be significantly increased through reduction of onsite evapotranspiration losses. Research in this area has much promise, and should return highly for the investment made. For example, removal of aspen overstory on plots reduced soil moisture depletion 6 to 8 inches, thus indicating a potential increase of this amount in streamflow. Various treatments at these high elevations may also improve the timing of water yields by increasing the base flow or by extending and flattening the snowmelt runoff peak.

Generally, the quality of water leaving the high country is good, and needs only to be maintained in this form through proper watershed management practices. Through rehabilitation and establishment of adequate protective plant cover, the problem areas in the high elevation watersheds which do yield sediment-laden water can be much improved. The research necessary here is primarily done by the Watershed Rehabilitation and Protection Project (INT-1603), with this project cooperating as needed.

At low and intermediate elevations, where precipitation is less than 20 inches annually, the native vegetation consumes almost all of the annual precipitation. What little water is yielded from these low lying watersheds is usually of poor quality--being high in dissolved salts and often laden with sediment. Here, the quality of water yield to the streams could be much improved through the establishment of adequate watershed protection. Such protection may be afforded by converting substantial areas of the common pinyon-juniper in the lower zone to a more dense forage cover. The quantity may also be increased somewhat by reducing evapotranspiration losses on the intermediate elevation watersheds. Conversion of the oakbrush-mountain maple type to a plant cover requiring less water might improve timeliness and increase flow.

Problem Areas and Their Priority

This project has four problem areas, within which well-planned water yield improvement research should produce substantial benefits. They follow in order of priority:

1. Improve water yields from the Wasatch and Uinta Mountains and the Wasatch Plateau. Improvement, in this instance, means an increase in quantity, better timing of delivery, and at least maintenance of present quality. Goals to be sought are increases in quantity or improvement of timing of such degree that recommended treatments are economically feasible. This problem area encompasses high elevation watersheds generally covered with aspen, mountain brush, spruce-fir, subalpine vegetation, and montane sagebrush. Research will be

pointed toward assessing present water balance, developing evapotranspiration reduction methods by cover manipulation and abiotic means, selecting low water-consuming adaptable species, and developing techniques to facilitate cover conversion to these species while maintaining soil stability, and an economic evaluation of treatment for water yield improvement.

2. Water yield improvement in the pinyon-juniper and lower elevation sagebrush-grass watersheds. The aim of research on this problem is to improve the quality and, to a lesser extent, the quantity of water yields. At these lower elevations, less precipitation is received; so less water can be yielded to streamflow or the ground water table. However, the quality of water yielded to streams may be improved if we can establish better watershed protection. The quantity may also be increased somewhat by reducing evapotranspiration losses on the watersheds. Impressive results have been produced by wildlife habitat research in converting pinyon-juniper to forage vegetation. While no measurements of sediment reduction have been made as a result of this treatment, it appears that water quality might be improved by these or somewhat similar treatments in this zone. Research is needed on techniques, adaptable species, and economic returns. Streamflow of slightly increased quantity and much higher quality from these intermediate and lower elevation watersheds would be of great benefit to the Region. Related water yield improvement research on watersheds of this type is being done by the Rocky Mountain Forest and Range Experiment Station in Arizona and by the Agricultural Research Service in Idaho. Results from this research will influence our future research effort on these lower elevation watersheds.

3. Improvement in water yields along the east Sierra Nevada. As pointed out earlier, 35 percent of Nevada's rapidly growing population lives in the Truckee, Carson, and Walker River Basins. These people live in the "rain shadow" of the Sierra Nevada, and are entirely dependent upon these mountains for their water supply. Increases in quantity of streamflow would have ready use. The extension of high flows later into the summer and reduction of flood peaks would alleviate the periodic incongruous problem of floods in the desert. Water quality could be improved from some areas by providing better vegetative cover on these fir-pine-brush watersheds on the east side of the Sierra Nevada. This problem is closely associated with the rehabilitation problem of Project 1603.

4. Improvement in timing of water yields from intermediate and high elevation watersheds throughout the Region. Large reservoir construction is impractical on many rivers within the Intermountain Region. Yet, these rivers and streams are important water supplies for many people. Without reservoir storage, the water supply can vary manyfold from year to year in this semiarid region. Usually, the

spring and early summer flow is in excess of need and the late summer flow is critically low on these unregulated streams. If watershed treatments that extend the high flows later into the summer and reduce flood peaks are developed for application to these unregulated drainage basins, the regional economy would be significantly enhanced.

Problem Selected for Study

Fundamental research in water yield improvement likely would apply to all problem areas listed, while the applied work--especially the empirical testing of ideas and techniques--would be restricted in usefulness to only the area for which it was developed. Priorities are assigned subjectively on the basis of the importance of the problem in the regional economy and well-being and on the likelihood of research success in the area.

The first problem area, water yield improvement in the Wasatch and Uinta Mountains (including the Wasatch Plateau), is given first priority because of: (1) The importance of an increased supply of good water to the rapidly growing urban complex on drainages along the Wasatch; (2) the need for an increased water supply in the Colorado River (the system into which much of the Uintas drain); (3) the large background of research data on water yields from this area (Davis County Experimental Watershed and Great Basin experimental area); (4) the current research efforts toward water yield improvement in this area by Utah State University and the Intermountain Station; and (5) the likelihood of success in the research endeavor to be of significance in watershed management. The high elevation lands in the Uinta and Wasatch ranges produce large quantities of water per unit of watershed. If a small percentage increase in yield can be achieved through the application of research results on these watersheds, a large increase in total water available for downstream use will be effected

All four of the professional project personnel are now headquartered in proximity to the first problem area. These scientists can effectively approach that problem as a team. Within the ensuing 5 years, some significant results can be achieved with the present financing and staffing (four scientists, three technicians, and clerical help as needed), if we concentrate on the top priority problem area. Proliferation of effort into the other three areas would be desirable only with increased staff and financial support.

Division of Research Effort Toward Solving The Top Priority Problem

The research effort toward solving the top priority problem and, to some degree, the other problems, is divided as follows:

1. Assessment of present water balance condition on these watersheds. Many parameters in this facet of the research endeavor are already known or estimated as a result of earlier work on the Davis County Experimental Watershed, on the Great Basin experimental area, and elsewhere. However, to effectively evaluate treatment results, we must develop a greater knowledge of water balance on the range of vegetation types, edaphic conditions, geologic complexes, and microclimatic conditions which prevail. In addition to inventory work and the review of present knowledge (much of which is not published), research, using accepted techniques on soil moisture depletion, the total water balance, and, perhaps, the energy balance, needs to be done so a greater understanding of the functions of Wasatch and Uinta watersheds may be gained.

2. Development of potentially useful vegetation-type conversion techniques. It has been proved that, under the proper conditions, the amount of evapotranspiration loss for the total growing season will be less for some plant communities (i.e. grass) than for others (i.e. deep-rooted trees) occupying similar sites. Increased streamflow has resulted from removal of vegetation from watersheds. Therefore, it seems plausible that increased quantity and, perhaps, improved timing of water yields from some Wasatch and Uinta watersheds, would be effected by converting them to vegetation types which consume less water. To accomplish this conversion, we must: (1) Ascertain the water-use characteristics of potentially desirable plant species; (2) determine the physiologic requirements of desirable species; (3) characterize the environment on potential conversion sites; and then (4) test likely species on apparently suitable sites. Along with the selection of suitable species-site combinations, we must develop economically feasible conversion techniques which the watershed manager may use to remove the present vegetation and establish the new vegetation, site by site.

Fortunately, we have some knowledge (gained through range management research) to draw upon, which makes this facet of the water yield improvement effort much less formidable than it would be otherwise. Continued close cooperation with Projects INT-1704 (Management of Herb-land, Brushland, and Aspen Ranges), INT-1803 (Game Range Restoration and Wildlife-Livestock Relations), and INT-1603 will speed the attainment of research results in this area.

3. Development of evapotranspiration reduction methods by manipulating the existing plant communities. This approach is somewhat in

contrast to that outlined in No. 2 above. However, it is important and valid because vegetation-type conversion is not appropriate on many sites, due to conflict with other uses, destruction of aesthetic values, or economic considerations. Further, it may be possible to develop treatments which may result in a savings of water, even when applied to those vegetation types which now use only limited amounts.

The hydrologic effects of various intensities and patterns of thinning in forest and brush stands should be tested. The alteration of age classes in communities may influence water yield; i.e., changing a mature stand to a stand of sprouts may temporarily affect water consumption. Pruning live crowns may have a significant influence on some sites. These conventional treatments should be applied in the forest and brush types, and the effects on water yields measured. Use of modern herbicides may make treatments quite economical.

If transpiration can be reduced by applying long lasting chemicals, without causing plant mortality, water savings might result which would not conflict with other watershed uses. This would have tremendous importance in the face of ever-increasing pressures for several uses of typical watershed lands. Some chemicals are known that reduce water loss when applied to plants or soil. Usually, their effects are short lived. Very little testing of these chemicals has progressed into field or watershed experiments. Much remains to be done in chemical development, application techniques, and controlled plant physiology experimentation before successful watershed-size experiments can be expected. We should pursue this approach to increasing water yields, culminating it with field tests of the most promising chemical applications. We are cognizant of the dangers of improper use of chemicals. Caution will be diligently exercised in all applications. Senate Report No. 1379, Pesticides and Public Policy, and the Use of Pesticides by the President's Science Advisory Committee provide guidance.

4. Development and testing of abiotic means of reducing evapotranspiration. Although transpiration and evaporation from a watershed can be altered effectively through vegetation treatments, other possibilities exist for changing the water balance on a watershed. Timing and quality of water yields and, perhaps, quantity, can be affected by ponding water in contour trenches or pits where the rain falls. This permits it to infiltrate the soil and leave the watershed as delayed runoff, probably as base flow rather than sediment-laden, flash overland flow. Surface runoff may also be placed directly into the ground-water aquifers through strategically placed recharge wells. Wetting agents, applied to lyophobic soil or litter, may improve infiltration and have the same effect as the mechanical treatments mentioned above.

In contrast to the improvement of infiltration, we may wish to reduce or prevent it where adequate storage facilities are available downstream. Emplacement of impervious mulches and paving of critical

watershed areas will force all runoff into channel flow and rapidly route it to a reservoir site. This approach should be tested for application to critical areas or for specialized uses.

Most precipitation on Intermountain Region watersheds occurs in the wintertime and is in the form of snow at high elevations. The distribution of the snowpack, its time and rate of ablation, and the amounts of evaporation from the pack, all have the potential of being influenced by watershed treatments. Hence, snowpack manipulation may improve water yields. Use of knowledge gained through the research in the Rocky Mountains and the Sierra Nevada will aid us in designing studies which show promise of improving water yields through snowpack manipulation in the Intermountain Region.

Coordination

At several places elsewhere in this statement, references have been made to coordination needs with other Intermountain Station projects and with outside agencies. In summary, coordination is needed with INT Projects 1601 (Streamflow Regulation in Northern Rocky Mountain Forests), 1603 (Watershed Rehabilitation and Protection), 1704 (Management of Mountain Herbland, Brushland, and Aspen Ranges), 1803 (Game Range Restoration and Wildlife-Livestock Relations), and INT 2102 (Fire Management). Project 1601 is concerned with streamflow regulation in northern Rocky Mountain forests, and its research toward reducing peak discharges and extending base flow may result in techniques of value to Project 1605. Studies conducted by Project 1603 on the physiological requirements and tolerance limits of selected plant species, microclimate of high-elevation harsh sites, and restoration of adequate vegetative cover for watershed protection are of interest to Project 1605. Project 1704 is concerned with management practices on high elevation ranges. These practices, relating to utilization of plant cover, bear directly on evapotranspiration and water yields from these ranges. This project is also conducting studies of mutual interest on the physiology and ecology of high elevation range species. Coordination is needed with Project 1803, especially regarding the ecological study of aspen, research on revegetation having to do with shrubs and forbs, and the evaluation of impacts on habitat resulting from cover manipulation. Project 2102, concerned with the use of prescribed fire on forest lands, is working in an area of mutual interest with this project. The effects of prescribed fire on the quality and quantity of water yielded from burned areas need to be evaluated. Problem analyses and appropriate study plans should have widespread review among these projects. Opportunities for conducting joint studies, to serve mutual interests, should be explored and implemented where feasible.

Finances

The gross budget for Project 1605 in F.Y. 1967 is $92,256. This includes a small allocation to Ephraim and the entire operation of the Davis County Experimental Watershed at Farmington. This budget pays the salaries of four full-time scientists, three full-time technicians, the project's share of the clerical salaries at Logan, and temporary help as needed. This austere level of financing permits only limited research in the top priority problem area. Long-term staffing plans call for two additional scientists and approximately three additional technicians.

Prepared by: Otis L Copeland, Assistant Director _____
Date

Concurred by: _____, Project Leader _____
Date

Concurred by: _____, Station Director _____
Date